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BIOLOGY.—*The measure of population divergence and multiplicity of characters.*[1] ISAAC GINSBURG, U. S. Bureau of Fisheries.
(Communicated by WALDO L. SCHMITT.)

In two previous papers (1937 and 1938) I discussed the problem of the species and its subdivisions and concluded that the lines drawn between these taxonomic categories must of necessity be arbitrary. In the later paper I employed a method for determining the precise divergence between natural populations, based on the character showing the greatest divergence (designated by Davenport, 1898, as the principal character, and the same term used in this paper), for the purpose of drawing pertinent arbitrary lines between those taxonomic categories. The question of multiplicity of characters was mentioned only in a passing manner. This paper takes up this question in some detail.

The determination of divergence may be considered with reference to time and to extent. Each one of these two factors may be considered further with reference to a single character and to a number of characters.

Time is, of course, an important element in divergence. With reference to time, changes that result in the differentiation and isolation of populations from preexisting populations, as manifested by any one character, may be roughly divided into two categories: rapid and slow. The former class may be called explosive evolutionary changes. Changes sometimes designated as mutations are of the explosive kind. (Geneticists have appropriated the use of the word mutation to express the idea of a change in the gene of any kind or degree. I use the word in the original sense, that is, to signify a perceptible change that is sudden, stable, heritable, and of appreciable magnitude, no matter what its immediate cause may be. We need two separate words to express these two ideas.) While probably not infrequent, it is apparently not the usual *modus operandi* of nature in evolution. The biological evidence adduced up to now makes it apparent that evolution, the differentiation of new populations from

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preexisting ones, usually takes place by slow changes. It may be assumed that, in general, each succeeding generation—or at least some individuals thereof—differs, in any one given character, very slightly from the preceding one. The difference between any two successive generations, considered in their entirety as separate populations, is usually so slight as to be imperceptible by our rather crude methods of observation and measurement. But the minute differences are cumulative, and when any two widely separated generations are compared, they may be detected by statistical methods. (It may be possible to test now the truth of this assumption. Possibly some museum has an adequate sample, collected a hundred or so years ago, of a population of plants or animals that reproduce annually and that have a short span of life, say, one or two years. Such a sample, when compared with a sample of the same population as it exists today, would represent an interval of 50 or more generations. With respect to evolution, biologists are usually in the habit of thinking in terms of geological time; but hardly anything is known now in regard to the time factor in evolution. Possibly in some cases an interval of even 50 or 100 generations may produce cumulatively, under natural or wild conditions—leaving out of consideration laboratory or domesticated conditions—a very small but statistically measurable difference. Crampton (1916, pp. 57, 120; 1932, pp. 78, 95) presents evidence to show that some populations of terrestrial gastropods of the genus *Partula* have undergone average morphological changes, sometimes to a considerable extent, during an interval of a little over half a century, as well as changes in their geographic distribution. Although no detailed observations appear to be extant on the span of life, the age at maturity, and the time frequency of reproduction in *Partula*, it seems safe to assume that a year represents the time interval of one generation and quite probably more than one.)

Though time no doubt plays an important role in evolution, it is hardly of practical importance in discussions of the species problem. For one thing it can not now be determined with anything approaching precision, or, more generally, it can not be determined at all. It is also reasonable to assume that there is no sharp line of demarcation between the above two classes of change with respect to time, and that one gradually merges into the other. We recognize only extreme examples of the explosive kind that happen to come under our observation and designate them as mutations. Even in populations undergoing comparatively slow changes there are apparently all degrees of differences in tempo. In general, it is obvious that some

populations, especially those belonging to certain genera, are now in a state of flux, actively changing and proliferating (the taxonomically so-called "difficult" genera are of this kind), while others show no perceptible change during long intervals of time, hardly differing even from their remote, fossil ancestors. Consequently, even if it were possible to use the time factor in determining divergence, we would have to draw arbitrary lines there also, the same as in the determination of the extent of divergence. Furthermore, the time factor, taken by itself, can not be used as a universal criterion in determining divergence. It is obvious that this factor depends on the span of life, age at maturity, fecundity, and length of the reproductive period of the particular population. Primarily it depends on the interval of time occupied by a generation, which, from this standpoint, may be taken to be its actively reproductive period.

Chiefly from a practical standpoint, therefore, the extent of divergence is the important thing to consider. If pairs of closely related, natural populations diverge to approximately the same extent, at least by the principal character, they are to be regarded as of the same taxonomic rank no matter whether they diverged by explosive or by slow evolutionary changes of different degrees.

In determining the extent of divergence the usual existence of a multiplicity of characters introduces a disturbing element. If closely related diverging populations differed by only one character, the extent of their divergence could be expressed readily and almost completely by the measure employed in my paper referred to (1938), or by some similar measure. But diverging populations usually differ in more than one character. The diagram I presented (1937, p. 187), to illustrate the gradual series obtained when the divergences of the chief distinguishing character or the principal character of a number of pairs of populations are arranged in order, may also be used (omitting the horizontal lines) as a general graphic illustration of the divergences of several characters between a single pair of populations. That is, when two closely related diverging populations are carefully studied, we find that usually they differ in several characters showing different degrees of divergence. The difficulty introduced by the usual existence of several diverging characters as between any given pair of populations was obviated by me (1938) by using the principal character as the basis of determining and measuring the extent of divergence. This method is seemingly incomplete. How are we to express the degree of divergence of two closely related populations by taking into consideration other characters in which they diverge

in addition to the principal character? What weight, if any, are these other characters to be given in measuring divergence? An altogether satisfactory answer to this question can not be given at present; but apparently not much weight should be placed on the other characters.

The problem of the measure of divergence as related to a multiplicity of characters may also be considered with reference to time and extent. With respect to time it is reasonable to assume that when a pair of populations diverge in more than one character, the several characters, in general, change about simultaneously, although this is probably not always and not altogether so. Consequently, it seems probable that the time element is usually of not much importance in determining the hypothetical sum total of divergence of all the characters. As far as the time factor is concerned, the principal character apparently forms an adequate basis for a measure of divergence. In any case, the time factor is not definitely determinable, and we are forced to leave it out of consideration in practice. While the time factor is of much theoretical interest, its consideration at present must be almost altogether of a speculative nature. For practical work in taxonomy we must rely on the extent of divergence. This is the factor of much practical importance in taxonomy, and it may be determined with some measure of precision.

(Geneticists may be dissatisfied with some of the above statements. For instance, some would probably object to the idea of changes being cumulative in an accretive sense, with reference to degrees of magnitude in the development of a given character; and would restrict the idea to a statistical sense, that is, the gradually cumulative addition to the population of individuals showing a given change or changes. With respect to any one presumably single factor character, they probably would express the idea of a cumulative change in a population in their language, in terms of a change, for some largely unknown causes, in the frequency ratios of alternative alleles. With respect to several characters, or any one presumably multiple factor character, they may want to express the idea as the statistical accumulation of mutant genes in the population. However, I am speaking here from the point of view of the taxonomist. The chief cause of difference in the points of view of taxonomists and geneticists is that the latter deal mainly with a particular and comparatively restricted kind of differences, qualitative differences; whereas taxonomists deal with all kinds of populations, and the great majority of closely related populations differ quantitatively, not in the absolute, but in having different frequency distributions that very often overlap, even in those populations that are generally regarded by taxonomists as of the rank of species. Because of the difference, by and large, in the material with which they work, they even think in different terms. Geneticists usually think of characters as of something being present or absent, or as of something that may manifest one form of two or more alternative and more or less discrete forms. Taxonomists, on the other hand, in consequence of the things with which they are more

familiar, generally think of characters as being variables that vary in a gradual manner about a more or less central mode, and in case of continuous variables, in virtually infinitesimal gradations. Another consequence is that in considering divergence between closely related populations, geneticists appear to think of and often lay stress on its being discrete or discontinuous, whereas taxonomists think in terms of degrees of magnitude that are virtually infinitesimally graded.

If current ideas regarding multiple factors and manifold effects of single genes are accepted as a working hypothesis, the proposition of a cumulative change in degrees of magnitude of a gradually variable quantitative character is not excluded, on the assumption that the change in the visible character is due to changes in a number of genes. Therefore, no matter how the propositions are stated, they refer to the same conclusion, that is, the usual way in which perceptible evolutionary changes in populations are brought about in nature is by the slow accumulation of minute differences.

The business of the taxonomist is to distinguish populations—species, subspecies, and races—by their visible morphological characters. The determination of their genetic constitution is a coordinate but, in practice, a separate problem. While a good beginning has been made toward an understanding of the operation of the genetic factors in heredity, it is only a beginning, and it may be expected that current hypotheses will be modified with increased knowledge. What the taxonomist is doing is to study the end products of the very complex interaction of genetic factors. A proper synthesis of the two closely allied branches of biology, genetics and taxonomy, is sorely needed. Perhaps, in the present state of knowledge, the time is not yet ripe for such a constructive synthesis. Meanwhile, I am here speaking the language of the taxonomist. The statements made above flow as a a plausible consequence of his experience. They also do not seem to be in conflict with the known facts so far uncovered in genetic studies.)

The *extent* of divergence of a multiplicity of diverging characters may be considered by referring to some hypothetical populations. Let us assume a pair of closely related populations, *alpha* and *beta*, that differ by two characters, *A* (Fig. 1) and *B* (Fig. 2). The divergence of character *A* is such that no intergrades exist; that is, the extent of divergence is 100 percent, every individual may be definitely referred to one or the other population on the basis of this character; while character *B* shows a very high degree of intergradation. Let us assume further another pair of population, *gamma* and *delta*, that also differ by two characters, *C* (Fig. 3) and *D* (Fig. 4), both characters showing a moderate degree of intergradation. Character *D*, as indicated in the figure, is assumed to show a slightly higher degree of intergradation than *C*, and *C* is, therefore, the principal character as between these two hypothetical populations. In this hypothetical case a number of individuals are not definitely referable to either population on the basis of any one character. When both characters are considered a number of such intergrades will likely be placed with a satisfactory measure of assurance by one of the characters falling

near the mode or even near the outer extreme end of the distribution of its population; but a residue of the individuals will likely have both characters intergrading.

Judged by criteria now in practical use by biologists in distinguishing populations, it is evident that the first pair of the foregoing two hypothetical pairs of populations shows a relatively greater extent of divergence than the second pair, because every individual, without exception, can be definitely referred to its proper population. The relative degree of divergence between the first pair of populations,

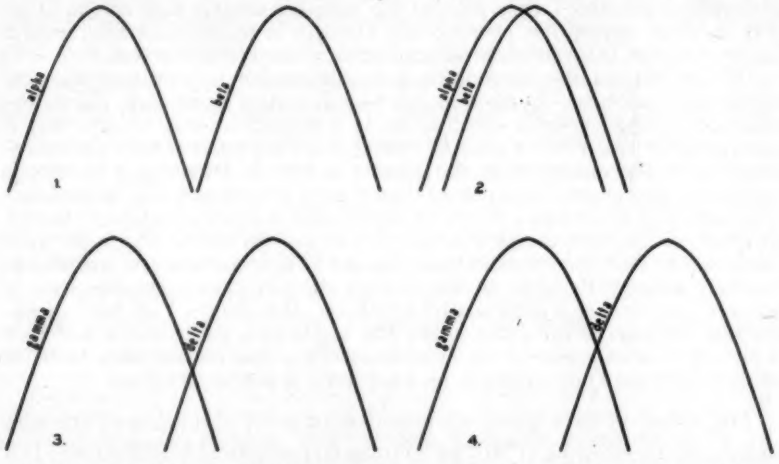

Fig. 1.—Graphic representation of frequency distributions of character *A* in two hypothetical populations, *alpha* and *beta*. Fig. 2.—Graphic representation of frequency distributions of character *B* in two hypothetical populations, *alpha* and *beta*. Fig. 3.—Graphic representation of frequency distributions of character *C* in two hypothetical populations, *gamma* and *delta*. Fig. 4.—Graphic representation of frequency distributions of character *D* in two hypothetical populations, *gamma* and *delta*.

as compared with that between the second pair, may be indicated by some measure expressing the extent of divergence of the principal character in the two pairs, characters *A* and *C*, respectively. But how are we going to combine the divergence of the two characters in each pair of populations in order to compare the relative divergence of the two pairs? Apparently a combination that will include the full measure of divergence of each character separately will likely show a higher relative divergence of the second pair of populations, a misleading result. If we are to include the lesser diverging character in the measure of divergence, it must be weighted, and weighted so that it will have only a very minor effect on the measure as determined by the

single character showing the greatest divergence. The development of a satisfactory method of weighting to produce a pertinent index of divergence is problematical. It seems apparent that a measure of divergence based only on the character showing the greatest divergence is fairly adequate, although perhaps not altogether complete, as an expression of the relative divergence of the above two hypothetical pairs of populations.

It should not be difficult to find in nature examples approximately corresponding to the above hypothetical cases. The same order of reasoning may be applied to three or more characters, and to the untold multitude of actual cases that may be encountered in practice.

Measures that have been proposed based on a combination of several characters are unsatisfactory. A few examples of such measures are next cited and discussed.[2]

Physical anthropologists have been using such a measure, designated as the "coefficient of racial likeness." This was devised chiefly for use in cases in which only small samples are available, on the assumption that the study of many characters and the combination of the sum of their differences in a single figure will compensate for the paucity of individuals studied and yield comparative figures that would be more reliable than those based on the comparison of a single character (see Pearson, 1926). Of course, the same measure may be applied to samples of fair or large size. The formula in use for determining this measure depends chiefly on the following factors: (1) the difference between the means of any one character of the two populations compared, (2) the standard deviation, (3) the number of specimens in the samples, (4) the summation of the values for the separate characters, (5) division of the value obtained by the number of characters. When a sample is small the standard deviation determined by it is unreliable, and that of the nearest related population for which an adequate sample is available is employed on the assumption that anthropometric data usually have a nearly normal distribution and that there is not much difference between the standard deviations of the different populations.

Seltzer (1937) discusses some of the errors and fallacies inherent in the "coefficient of racial likeness" when used as a measure of di-

[2] Students of the differing frequency distributions of blood groups in different populations of the genus *Homo* have been using a "biochemical index" or other indices to express population differences in terms of a single figure. These indices do not represent a combination of two or more characters, but a combination of percentage ratios of frequencies in the same distribution. As may well have been expected, such indices as well are inapplicable and sometimes misleading (see Wiener, 1935, pp. 153–154).

vergence, as follows: (1) For any given character, it assumes arbitrarily and unjustifiably a single standard deviation for different populations. (This objection may be overcome when the samples compared are of fair size, and the standard deviation of each population separately determined.) (2) It depends on the number of characters used in the comparison. (3) It depends on the number of specimens in the samples. (4) Fundamentally, it is not a measure of divergence, but rather an expression of probability. (5) What is most important of all, Seltzer shows that biologically it is altogether inapplicable, because it results in absurdly misleading conclusions. (The last three objections I raised in my 1938 paper in connection with the application of current formulae to a single character for the purpose of measuring divergence. The very fact that the coefficient of racial likeness is an expression of probability should lead one to expect that it will often result in false conclusions when used as a measure of divergence.)

Much simpler methods of combining several characters have been employed by some students of fishes in comparing populations or samples. Hubbs and Whitlock (1928, p. 471) compare two samples by determining the value of a ratio the numerator and denominator of which represent the products of measurements of certain parts, respectively, of the head and body. Koelz (1929, p. 426) also uses a ratio to express, in part, the difference between two populations (designated by him as subspecies), but the numerator and denominator represent the sums of the numerical value of two measurements. Schultz and Welander (1934, p. 6) employ the simple addition of the number of anal, dorsal, and both pectoral rays to determine the difference between two species. Similarly, Hubbs and Kuhne (1937) employ the sum of the numbers of anal, dorsal, ventral, and pectoral rays and the scales to determine the difference between two populations (designated by them as subspecies). Schultz and Schaefer (1936, p. 5) go a step farther and compare certain populations by both the addition and subtraction of the numerical values of certain characters, and the same device is employed by Schultz and Thompson (1936, p. 74), by Schultz and Reid (1937), and by Schultz (1937, p. 19).

By any of the above devices of combining characters, the numerical value of the combination is determined for each individual separately. A frequency distribution may then be arranged based on the individual numbers thus obtained.

For the purpose of determining relative divergence, or the taxonomic rank of the particular pair of populations compared, the combination of characters as determined by the above workers is inapplicable because it will prove to be misleading in many cases. Its use as a measure of divergence is therefore excluded for this one reason, outside of any other consideration. It is readily conceivable that by the use of such figures in the form of frequency distributions, some races may be shown erroneously to diverge to a greater extent than some species. It should not be difficult to find examples in nature to prove the truth of this assertion.

Judged by the evidence presented in one of the papers cited above, that by Schultz (1937), the two populations compared, *Mallotus villosus* and *M. catervarius*, are evidently not more than races, or subspecies at the most. Schultz compares in detail a larger number of characters than usual in such cases. It is work done in a thorough manner by methods that will help us solve the species problem. It is unfortunate, therefore, that his frequency distribution tables were not published, so that we could judge the precise divergence of every character separately. However, judged by the summaries of his data presented, the ranges and the means, it seems evident that the two populations intergrade widely in every character. Yet, when a certain number of characters are combined, by addition and subtraction, a frequency distribution is obtained that even shows a gap between the two populations. It should be possible to obtain the same result with many pairs of races if they are studied in as great detail as Schultz studied the pair of populations mentioned.

Another important matter to consider in this connection is the number of diverging characters. Let us take, for instance, two populations, *epsilon* and *zeta*, whose divergence in one character is close to 100 percent, or, concomitantly, intergradation is close to zero; and suppose, furthermore, that they do not diverge very appreciably in any other character. Nearly every individual may thus be referred to either population by the single, widely diverging character, and the two populations are to be properly regarded as distinct species. Now, let us suppose two other populations, *eta* and *theta*, that differ by, say, ten diverging characters, and furthermore, that there is considerable intergradation in every character, so that divergence of any one character is not more than of racial magnitude. In that case the two populations are to be properly regarded as of racial rank only, yet if the numerical values of the several characters are combined by the methods employed by the above authors, the two populations may

show a high degree of divergence, perhaps even a gap between them, higher than the divergence between populations *epsilon* and *zeta*. The two populations studied by Schultz, mentioned above, apparently constitute an example very similar to our hypothetical *eta* and *theta*.

The foregoing discussion relates chiefly to the device of combining the numerical value of characters by addition and subtraction. The same misleading results will be obtained by combining characters in the form of ratios or by division. A consideration of this manner of combining characters may be simplified by reducing it to its lowest terms, the combination of two characters. In the two hypothetical pairs of populations illustrated above, for instance, let us assume that character D differs in such manner that it has a greater numerical value in population *gamma* than in *delta*, that is, the left-hand curve in Fig. 4 represents *delta* while the right-hand curve represents *gamma*. Then, if we combine the two characters in the form $\frac{C}{D}$, it seems apparent that, for most specimens at least, the values $\frac{C}{D}$ will be relatively greater for *delta* than for *gamma*, than in the comparison of the values of C alone. (This will depend to some extent, in individual specimens, on the degree of correlation of the two characters in each one of the two populations; but in general, the above statement may be expected to hold.) Consequently, the two arbitrary frequency distributions obtained from the values $\frac{C}{D}$, representing *gamma* and *delta*, respectively, will evidently show a greater divergence than either C or D taken separately. On the other hand, if we suppose that the numerical value of the characters A and B remain as illustrated, then the arbitrary distributions obtained by the combination $\frac{A}{B}$ will likely show a lesser degree of divergence than that shown by the divergence of character A when considered by itself. In other words, by combining the two characters in each pair of populations as indicated, *gamma* and *delta* may show a higher degree of divergence than *alpha* and *beta*, evidently a misleading result. When the numerator or denominator, or both, are, in their turn, made to represent a combination of more than one character, by addition, subtraction, or multiplication, things become more complicated, but it is apparent from the foregoing discussion that combining characters in such manner will often result in misleading conclusions.

Such combinations of characters by addition, subtraction, multiplication, and division of their numerical values, when carried to their extreme as is done in some of the papers cited above, on the whole give the impression of a mere manipulation of figures rather than that of sound statistical treatment of the data. This impression appears

justified by the misleading results that are apt to occur. Fundamentally, what taxonomists are actually doing in distinguishing species, subspecies, or races, either by a numerical combination of several characters or by a consideration of every character separately, is to determine the relative degree of divergence; although this idea is often lost sight of on superficial thought. Our basis of comparison is, of course, always a single pair of populations. We determine to what degree a pair under consideration diverges and compare this divergence in relation to divergences shown by other pairs, either in a definite manner as I (1938) have suggested, or by rule of thumb as is usually done in taxonomic practice. That is just what most of the above-mentioned authors set out to accomplish, to determine by combining several characters the relative divergence of their populations, for the purpose of deciding whether they represent distinct species or categories of lower rank. For this purpose, their device of combining several characters is altogether misleading. What is particularly misleading in the use of such devices is that the arbitrary frequency distribution obtained as a result of the combination of the several characters may be treated by the ordinary statistical methods—as, indeed, a wholly mythical frequency distribution may be treated—to determine the value of the standard deviation, the probable error, the probability ratio, etc. Such treatment, seemingly, covers the figures with a cloak of statistical respectability, so to speak; it gives them a seeming validity. But, biologically, for the purpose of determining relative divergence, the figures are misleading, as discussed.

The foregoing devices of combining characters, in their extreme form, are carried to a point where they constitute almost a *reductio ad absurdum* going to prove their inapplicability. One is then compelled to reexamine the entire question more fully and work backward to the more simple forms. As a consequence, the applicability of some proper appearing, simple methods of combining characters is cast in doubt. For instance, it is the general impression among taxonomists that it is proper to use a ratio of two given measurements for the purpose of distinguishing species or populations of lower rank. I have used this method for distinguishing *Gobiosoma bosci* from *G. robustum* in my revision of their genus, and I used (1938) that comparison as one of the examples in establishing a gradual series of relative divergences. I (1929, p. 80) have also used the same method, in part, in comparing two populations of *Cynoscion*. Other taxonomists, and physical anthropologists in particular, sometimes

use character indices in the form of a ratio based on the numerical value of two measurements. Doubt is now cast on the propriety of treating the data in this manner for the purpose of determining relative divergence.

From this point of view, one of the general, basic methods of fish taxonomy needs a reappraisal. Measurements of various parts are generally used in distinguishing populations of fishes of specific or lower rank. The measurements are generally stated not as absolute values, but as the numerical value of a ratio, generally as entering so many times in the standard length (that is the combined length of head and body), or in the head. Sometimes a ratio is stated in percentage form. This method is adopted because measurements differ with the size of the individual, and consequently absolute measurements would often be of limited value unless they were based on individuals of approximately the same size. At any rate, measurements as generally employed in distinguishing populations of fishes are used as a combination of two characters. In view of the foregoing discussion, it may be asked, Do they form a legitimate basis for the determination of relative divergence?

It is well to emphasize here the distinction between two ideas or processes, namely, identification and determination of relative divergence. A combination of the numerical values of two or more characters to form an index may be useful in identifying specimens. However, identification is not the only function of taxonomy. By a comparative study of morphology taxonomists are also trying to interpret relationship. And what is of greater immediate importance, they are classifying populations into categories—species, subspecies, races, etc. For the latter purposes we need to determine relative divergence as precisely as possible, and for this determination the combination of the numerical values of several characters will often prove misleading. These values may be shuffled so that a pair of races may show a greater degree of divergence than a pair of species, and a pair of closely related species a lesser degree of divergence than a pair of races compared. It remains to be determined to what extent and how often the combination of two characters in the form of a ratio, such as the cephalic index of physical anthropologists, or the manner of expressing measurements employed by fish taxonomists, may be used in expressing relative divergence and how often it will be misleading for this purpose.

It has been stated above that for the purpose of a precise determination of relative divergence, the principal character constitutes a

basis for an adequate measure with respect to time and fairly adequate with respect to extent. Not only that, but the foregoing discussion makes it evident that it is the only proper basis now available. It is doubtful whether the other characters are to be considered at all in determining the measure of divergence, and in any case they should be afforded a very minor weight. The proper basis of determining such weights is not apparent now. In determining relative divergence every character must be considered separately, and apparently the best we can do now is to consider the other characters in a general way, in pairs of populations standing near the border line between the species and the subspecies, or the subspecies and the race, as determined by the principal character, as was suggested in my 1938 paper. The proper consideration of the other characters in this manner will, of course, depend on the thoroughness, skill, insight, and intuitive capacity of the taxonomist.

Other difficulties in the way of combining several characters appear altogether insurmountable. One of these is the possible existence of unequal numbers of diverging characters as between two or more given pairs of populations. This point has been raised above and hypothetical examples cited. Let us suppose further that one pair diverges in ten and another in twenty characters. Apparently, by combining all the characters in both cases, the two measures thus obtained will not express fairly the relative divergence of those two pairs of populations. To limit ourselves to a certain definite and equal number of characters in both pairs, as is done by Morant (1928), for instance, is a wholly arbitrary procedure; because on the assumption that the other characters, besides the principal one, are of importance in determining the measure of divergence, they should all be included in a determination of that measure for any one given pair of populations.

Another insurmountable difficulty is that it is practically impossible to study all characters. This is especially true if we are to include measurements of the head, body, or separate organs, or parts of the head, body, or organs, or the distance between any two given points, measurements by which distinct populations usually differ more or less. The number of such characters may be almost indefinitely increased. In practice, therefore, the number of characters studied necessarily must be limited, and the determination of divergence somewhat incomplete as far as it relates to the minor characters.

From the foregoing discussion the conclusion is reached that the principal character forms a fairly adequate basis for a measure of

divergence of a given pair of populations, which may be used in determining relative divergence in a series of pairs. It is the only appropriate basis now available. The other characters, if considered at all for this purpose, should be given very minor weights. In any case, it is practically impossible to include all the minor characters.

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PALEOBOTANY.—*Fossil plants from the Cretaceous of Minnesota.*[1] EDWARD W. BERRY, Johns Hopkins University.

In part 1 of volume 3 of the Final Report of the Geological and Natural History Survey of Minnesota there appeared a paper on the fossil plants prepared by the veteran paleobotanist Leo Lesquereux. This was published in 1895, and in it he identified 28 species of fossil plants, most of them well-known Dakota sandstone forms. He stated that they were entrusted to him for description by N. H. Winchell, the State geologist. The bulk of the material came from the banks of the Cottonwood River near New Ulm, but several are recorded from Mankato and from Goodhue County.

If the reader will consult the small scale geologic map that forms the frontispiece of the volume he will observe that considerably more than the western half of the State was thought to have been submerged by the eastern borders of the waters that flooded the great Colorado geosyncline during Middle and Upper Cretaceous times, and it has always seemed strange that no local geologist or paleontologist has been inspired to cultivate this field in the more than two score years since Lesquereux penned his report.

In January 1938, I received from Dr. F. M. Carpenter, of the Museum of Comparative Zoology at Cambridge, two specimens that had been submitted to him by Prof. Clarence Nickel, of the University of Minnesota. The specimens had been collected by Ludwig Koelnau, one-half mile north of Springfield, Brown County, Minn., and with the idea that they might represent some sort of an insect larva or pupa had been submitted to the Entomology Department of the University.

This locality is not far from the Big Cottonwood outcrop from which the bulk of the material came that was described by Lesquereux. My great interest led to Prof. C. O. Rosendahl's sending me in February of last year a small collection made from the Big Cottonwood outcrop, which is about 1 mile southwest of Springfield.

In addition to the pod mentioned above, there are several other things not before found in the Dakota of Minnesota, so that it is quite apparent that detailed and persistent exploration of this horizon would add considerably to the Cretaceous flora of Minnesota.

This brief note seems distinctly worth while to call attention to this neglected field aside from what it adds to our knowledge of mid-Cretaceous plants.

[1] Received March 1, 1939.

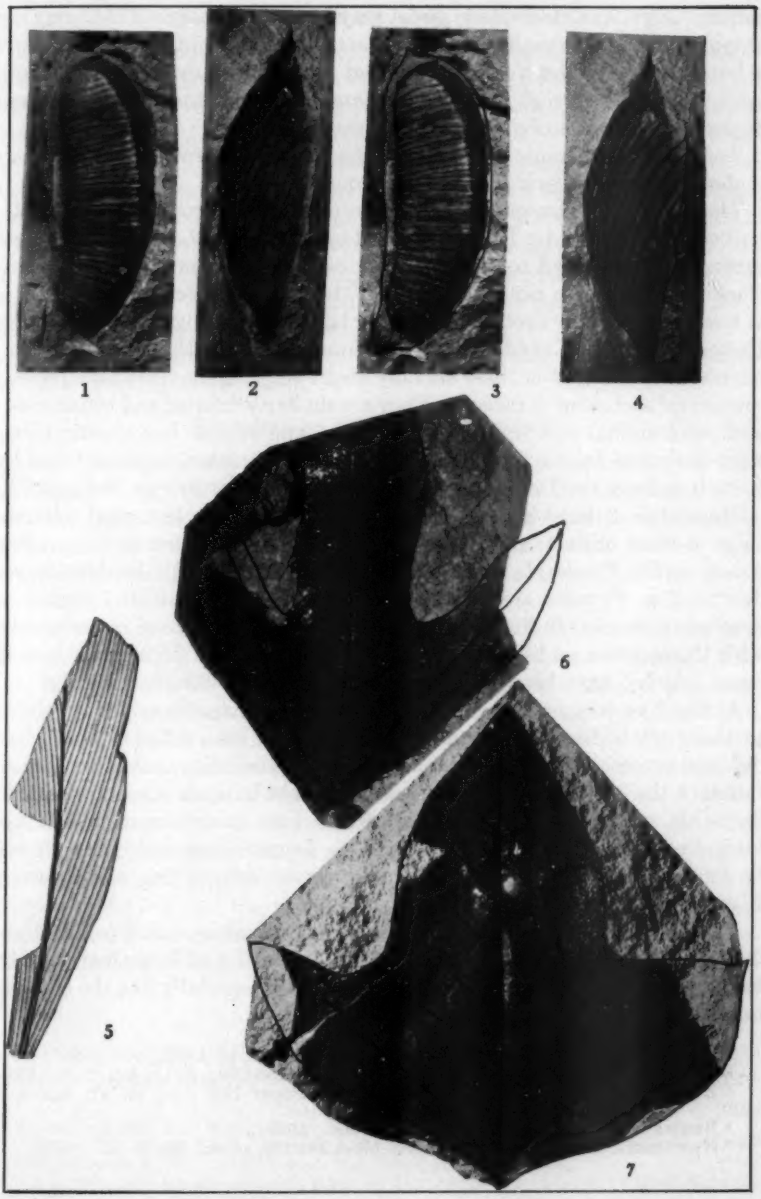
Capsulocarpus dakotensis, gen. et sp. nov. Figs. 1–4

As will be realized from what follows, the nomenclatorial problem raised by the present specimen is perplexing, and I have reached a tentative solution by proposing the botanically noncommittal pseudogenus *Capsulocarpus* in order that there may be a name for these objects. For the present it has the features of the type species, which may be characterized as follows:

Podlike capsule, which, from the nature of its outer surface, was probably indehiscent. Somewhat falcate in outline, abruptly pointed distad, narrowed to a short and stout peduncle proximad, inflated and circular or inflated lenticular in cross section, filled with approximately circular thin seeds at right angles to its axis. This appearance may not represent seeds but may be due to the transverse direction of the fibrous inner wall of the capsule, the suggestion that it may be due to the edges of seeds being furnished by certain existing forms in the family Bignoniaceae. An external impression of the capsule is furnished by the counterpart of the specimen shown in Figs. 1 and 3. This is marked by a series of shallow oblique curved ribs and depressions roughly parallel with the convex side which are rather sharp and distinct on this convex side, but which diminish in magnitude and become obsolete about halfway toward the concave side. The whole organ is slightly under 5 cm in length and about 1.7 cm in width. If the bas relief shown in the specimen was symmetrical in life it was about 1.4 cm in thickness.

There is an undescribed specimen of what must be regarded as the same thing in the National Museum collections, which I owe to the courtesy of Dr. R. W. Brown and which comes from the Dakota sandstone 12 miles west of Lincoln, Nebr. This is somewhat smaller than the Minnesota specimen but shows the same falcate shape and transverse markings as the Minnesota specimen. This is about 3 cm long and 7 or 8 mm in maximum width and at most could be considered a second species of the same genus. For the present there seems to be no ground for regarding it as a distinct species, particularly in view of the following: Lesquereux in 1868 described from the Dakota sandstone at Decatur, Nebr., what he called *Pterophyllum haydenii*.[2] In his Cretaceous Flora[3] he published figures, and in 1883 and 1892 he referred to it as *Podozamites haydeni*.[4] The original of Lesquereux's figure 6 can no longer be found, but I have before me the original of his figure 6b. This, although somewhat compressed and otherwise poorly preserved, is exactly like the Minnesota specimen and approximately of the same size. The artist has emphasized a series of parallel longitudinal lines in keeping with what should be seen in a cycad pinnule (such as Lesquereux thought the specimens to be) and has entirely ignored the much more prominent transverse lines like those shown in the Minnesota specimen (Fig. 1). Lesquereux's specific name has not been taken up for the present species because it also included later discovered remains, which he subsequently regarded as a species of *Abietites*, so that if I have violated the canons of

[2] LESQUEREUX, L. Amer. Journ. Sci. 46: 91. 1868.
[3] —— U. S. Geol. Surv. Terr. 6: 49, pl. 1, figs. 6, 6b. 1874.
[4] —— Ibid. 8: 27. 1883; U. S. Geol. Surv. Mon. 17: 26. 1892.



Figs. 1–4.—*Capsulocarpus dakotensis* Berry, n. sp. 1 and 3 the inner part, 2 and 4 the impression of the outer surface. 1 and 2 are from untouched photographs. Fig. 5.—*Protophyllocladus subintegrifolius* (Lesquereux) Berry. Figs. 6, 7.—*Sassafras acutilobum* Lesquereux.

nomenclature, some taxonomic purist may have the pleasure of changing my proposed name. The really important fact is that an identical species occurs in both Minnesota and Nebraska and that the supposed cycad in the Dakota sandstone flora, *Pterophyllum* and *Podozamites*, goes into the discard and disappears from paleobotanical literature.

Regarding the possible botanical relationship of these fossil fruits the story is about as involved as is the taxonomic one.

The present specimens at once suggested comparisons with a form described first in 1878 by Lesquereux and called *Carpolithes arachioides*, and subsequently changed to *Leguminosites arachioides* from a fancied resemblance to the modern peanut (*Arachis*). This form has been found at a score of localities near the Cretaceous-Eocene boundary throughout the Western United States and Canada and in the lower Eocene of the Mississippi embayment. The largest of these are only about one-half the size of the present specimens[5] and occur in racemes. They are similarly inflated and ornamented with longitudinal and transverse markings, and similar but smaller forms were described by me in 1930 as *Leguminosites arachioides minor*[6] and by Knowlton from the Denver formation of Colorado as *Berrya racemosa*.[7]

Meanwhile Brown[8] has discussed the question of the botanical relationships of these objects, and has shown that they are related to the existing Asiatic genus *Cercidiphyllum*, to which many of the early Tertiary leaves described as *Populus* are also related. Brown's proof, which I regard as conclusive, consists in finding at scores of localities the leaves in association with the capsules and characteristic tiny winged seeds. In a paper now in press, which I have been privileged to read, he gives complete details.

At first I was disposed to consider the Minnesota capsule as closely related to these trochodendraceous forms, but its large size, different habit, and different external ornamentation, as well as the possibility that the ornamentation of the inner capsule (Figs. 1 and 3) might indicate a column of disk-like seeds, suggested caution, and at present I am unable to suggest its botanical affinity. I doubt if it belongs to the Leguminosae and believe it will be found to represent some genus, perhaps an extinct one, of the family Bignoniaceae.

In connection with this material attention should be called to an object described by Newberry from the Raritan formation of New Jersey under the name of *Tricarpellites striatus*.[9] His figure 9 is especially like the external impression of *Capsulocarpus dakotensis*.

[5] See BERRY, E. W. U. S. Geol. Surv. Prof. Paper **91**, pl. 48, fig. 9. 1916.
[6] BERRY, E. W. U. S. Geol. Surv. Prof. Paper **156**: 89, pl. 14, figs. 2–6. 1930.
[7] KNOWLTON, F. H. U. S. Geol. Surv. Prof. Paper **155**: 134, pl. 41, figs. 4, 5. 1930.
[8] BROWN, R. W. Journ. Pal. **9**: 575, pl. 68. 1935.
[9] NEWBERRY, J. S. U. S. Geol. Surv. Mon. **26**: 132, pl. 46, figs. 9–13. 1895.

Protophyllocladus subintegrifolius (Lesquereux) Berry Fig. 5

The usually incomplete leaves or phyllodes of this species are the most abundant in the collection studied. Described first by Lesquereux[10] from the Dakota sandstone of Kansas and Nebraska as a fossil species of *Phyllocladus*, it was recorded from the Atane beds of western Greenland by Heer under the name of *Thinnfeldia lesquereuxiana*.[11] Newberry reported it from the Raritan formation of the Amboy district in New Jersey, and still later it has been found to be of common occurrence in the Magothy formation of the Atlantic Costal Plain, in the Tuscaloosa formation of Alabama, in the Frontier formation of Wyoming, in the Cretaceous of Alaska, and in Russian Sakhalin. Meanwhile other species have been described from Alaska, the Western United States, and Patagonia.

The Minnesota specimens are perfectly characteristic. Its botanical affinities have been much discussed.[12]

Sassafras acutilobum Lesquereux[13] Figs. 6, 7

Also relatively abundant in the present collection are leaves that are indistinguishable from this species, first described by Lesquereux in 1874 from the Dakota sandstone of Kansas, and since recorded from numerous additional localities, especially along the Atlantic and Gulf borders from Marthas Vineyard to Alabama in the Raritan, Magothy, and Tuscaloosa formations.

Lesquereux described many species of *Sassafras* from the Dakota, and other similar lobed leaves as various species of *Araliopsis*, *Platanus*, *Cissites*, and *Sterculia*. Their generic relations are extremely tangled and overlapping. Some of these are certainly related to *Sassafras* and some are not. The geological history of the genus is treated at some length by the present writer, to which account the reader is referred.[14] The Minnesota specimens are identical with those of the type from the Dakota sandstone. Any extended discussion is not pertinent in the present note and would be endlessly complicated by the jealousies growing out of the rivalry between Lesquereux and Newberry and the feeling engendered by the establishment of the U. S. Geological Survey and the liquidation of the Hayden Survey. While this rivalry was not so venomous as that between Cope and Marsh in the vertebrate field, it resulted in similar, if somewhat less marked, taxonomic tangles.

Laurus plutonia Heer

Several specimens of this quondam species are present in the present collection. It was first described by Heer from the Dakota sandstone of

[10] LESQUEREUX, L. Amer. Jour. Sci. 46: 92. 1868.
[11] HEER, O. Flora fossilis Arctica 6(2): 37. 1882.
[12] See BERRY, E. W. Bull. Torrey Bot. Club 30: 440. 1903.
[13] A fairly complete synonymy is given by BERRY, E. W. Maryland Geol. Survey. *Upper Cretaceous*, p. 866. 1916.
[14] BERRY, E. W. *Tree ancestors*, pp. 247–251. 1923.

Kansas and was doubtfully recorded by Lesquereux from New Ulm, Minn. It has also been recorded from a large number of Upper Cretaceous localities in West Greenland, along the Atlantic border of the United States from Marthas Vineyard to Alabama and Texas. The name *Laurus* does not imply a close relationship with the existing Old World species of *Laurus*, but it has been used by paleobotanists in the sense that a few wiser authors have used the pseudogeneric term *Laurophyllum*, implying some undetermined genus in the family Lauraceae.

ZOOLOGY.—Onychocythere, *a new genus of marine ostracod from Florida, with a description of one species.*[1] WILLIS L. TRESSLER, University of Buffalo. (Communicated by WALDO L. SCHMITT.)

Two specimens, a male and a female, of this ostracod were sent to the writer by Dr. Waldo L. Schmitt, curator of marine invertebrates, U. S. National Museum, for identification. They were collected by Miss Louella E. Cable from the stomach of a shad caught at Welaka, Fla., in the St. Johns River on April 1, 1938. The shad (*Alosa sapidissima*) had a total length of 478 mm and a standard length of 327 mm. There was very little food in either the stomach or intestine, as is the case with most of the adult shad examined. In the summer of 1936, two collections of shad totaling 58 specimens were taken from the Hudson River and were found to have been feeding on surface drift exclusively (Tressler and Bere, 1937). In the Florida shad the stomach contents amounted to only 4.0 cc, most of which consisted of tiny bits of plant material, rotted leaves, twigs, and grasses. In addition there were 30 copepods identified by Dr. C. B. Wilson as *Mesocyclops leuckarti* (Claus), 1 nematode, 4 daphnia identified by Dr. C. Juday as *Daphnia longispina* var. *hyalina*, 1 chironomous larva, 1 minute crab leg, and 6 ostracods. The ostracods consisted of the two specimens mentioned above and four specimens of *Cypria opthalmica*, a common fresh-water species. The shells of the marine ostracods were somewhat disintegrated (this was particularly true of the shell of the female), while those of *Cypria* were well preserved. It seems likely, therefore, that the marine ostracods had been in the stomach for some time before the fresh-water forms had been eaten. The calcareous shell is fairly resistant to the action of weak acids, and evidently the gastric juice requires a considerable period of time before the contents are available as food. The exact location of the habitat of this ostracod is, of course, indeterminable, but as the vast majority

[1] Received March 18, 1939.

of the family Cytheridae and all the known members of the subfamily Cytherinae are marine, it is logical to suppose that the shad had fed upon them in the ocean before entering the St. Johns River. All the members of the family Cytheridae are almost entirely devoid of natatory powers and are, as a consequence, strictly bottom dwellers. *Cypria*, on the other hand, is a very agile swimmer although many of the species keep close to the bottom.

The slides of the dissected ostracods have been deposited in the U. S. National Museum as type specimens.

Suborder PODOCOPA Sars

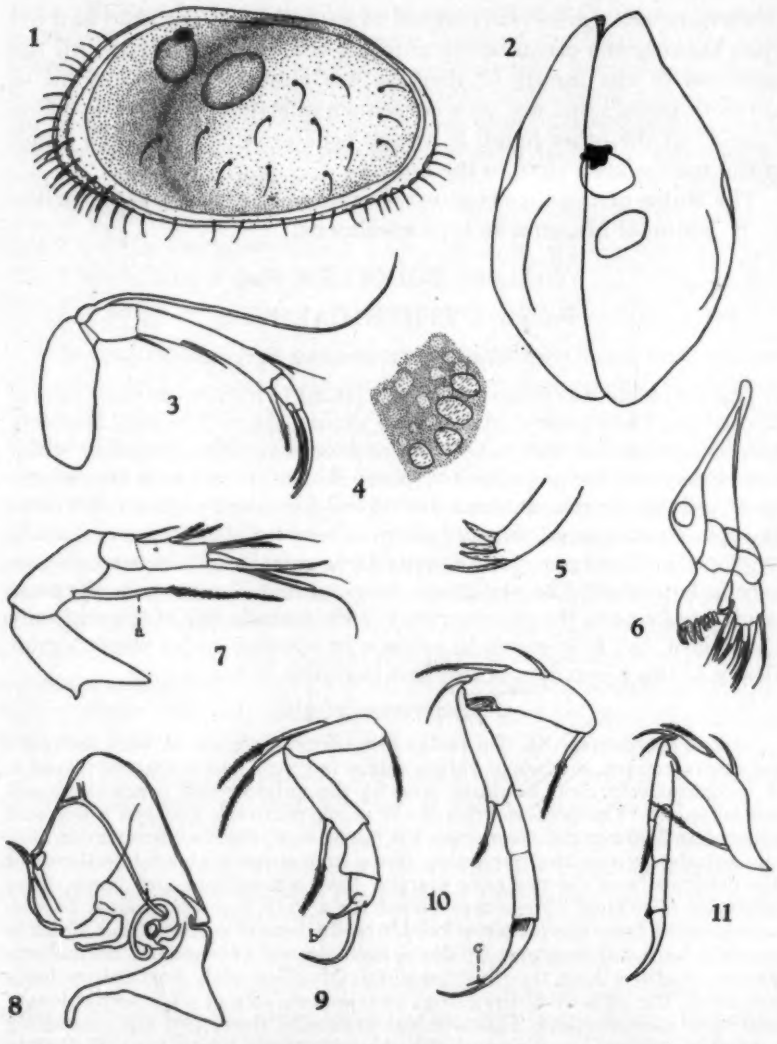
Family CYTHERIDAE Baird

Subfamily CYTHERINAE Sars

This subfamily was proposed by Sars (1928) to include the more typical Cytheridae; those closely allied to the genus *Cythere*. The shell is of very firm consistency and calcareous with a more or less sculptured surface, which may or may not bear projections or spines. Both of the antennae are strongly developed; the anterior antennae have 3 or 4 joints and possess 2 or 3 claw-like spines with several thinner bristles in between. The legs are normally developed in all the previously described genera and are of the same appearance in both sexes. The new genus described here departs from the usual conditions found in the characteristics of the thoracic legs of the subfamily Cytherinae, but as it seems to conform in all other major respects most closely to this group, it appeared best to include it here.

Onychocythere, n. gen.

Generic characters.—Shell of rather firm consistency but without sculpturing or projections. Surface of valves with a few very coarse scattered spines. A comparatively clear marginal zone at the anterior end bears numerous coarse spines. The posterior border is much narrower and has fewer and somewhat finer bristles. Seen from the dorsal side, the shell is rather tumid, the anterior extremities narrowing down from a point about two-thirds of the distance from the posterior margin. Eye, conspicuous and single. First antennae of normal appearance except for a very long and robust bristle, which arises from the posterior border of the second segment and which is coarsely haired throughout its distal half. Second antennae of normal appearance with a long tapering flagellum. Maxillae with masticatory lobes produced, the palp with three stout unarmed claws and a somewhat longer and more slender spine. Thoracic legs unequally developed and possessing several remarkable and apparently unique features which are sufficient to readily identify this genus. First leg, short and of normal appearance. Second leg, much the longest, with a thick terminal claw, which bears a peculiar aberrant bristle about one-third the length from the distal end on the posterior border. Third leg, short and heavily built with a recurved, slender terminal claw and a second short, heavy claw at its base. No differentiation of the legs in the two sexes.



Figs. 1–11.—*Onychocythere alosa*, new genus and species. 1, Lateral view of left valve of male. 2, Dorsal view (slightly tilted) of male. 3, Second antenna of female. 4, Muscle marks and detail of shell markings, female. 5, Spines of palp of masticatory lobe of maxilla of female. 6, Mandible of female. 7, First antenna of female. 8, Copulatory apparatus of male. 9, Third thoracic leg of female. 10, Second thoracic leg of female. 11, First thoracic leg of female.

Onychocythere alosa, n. sp. Figs. 1–11

Specific characters.—Female: Shell of oval shape, seen laterally, with broadly rounded ends, the anterior somewhat more broadly rounded than the posterior. Greatest height anterior to the middle. Ventral margin convex. Hyaline border widest anteriorly. Surface of valves without sculpturing but marked with a very delicate pattern of polygonal areas bordered by darker margins. The anterior margin gives rise to a number of very coarse bristles, which are also sparsely scattered over the surface of the valves. Posterior border with smaller and fewer bristles. Seen dorsally, oval in outline; greatest width in the center. Anterior ends attenuated; posterior broadly rounded. Eye spot, single and conspicuous. Valves nearly equal, the right being slightly longer than the left. First antenna of normal shape for this group except for a very long and heavy spine originating from the posterior border of the second segment (Fig. 7, *a*). Terminal half of spine coarsely haired. Second antenna with a long tapering flagellum. Palp of masticatory lobe of maxilla with three stout unarmed claws and a heavy spine. Legs much differentiated, the first being the shortest and least developed. The second leg is the longest and terminates in a heavy, slightly curved claw, which bears near its tip and aberrant bristle (Fig. 10, *c*). At the base of the terminal claw is a row of six short bristles. The third leg is by far the most highly developed of the three and, while shorter than the second, is very stout and bears a strongly recurved tapering terminal claw. At the base of the terminal claw is a second heavy, short claw (Fig. 9, *b*). The bristle on the posterior margin of the second segment is very heavy and is densely haired on its distal half.

Male: Shell of similar size and shape to that of the female. Bristles much coarser. Internal structure almost identical with that of the female, including the structure of the three thoracic legs, which show the same features found in the other sex. Copulatory apparatus very large, with the basal portion rounded triangular in shape. Below, it sends off a slight, short, nearly straight projection, which is slightly hooked at its extremity. Inside it is provided with a very much curled, thick cord. Terminal portion with a slightly blunt posterior end and a much elongated anterior projection which curves ventrally near the extremity.

Color of shell undetermined.

Length of adult female, 0.91 mm. Length of adult male, 0.99 mm; height, 0.54 mm; width, 0.61 mm.

Occurrence.—Taken from the stomach of a shad caught in the St. Johns River at Welaka, Fla., on April 1, 1938. Female holotype, U. S. N. M. no. 77805. Male paratype, U. S. N. M. no. 77806.

Remarks.—This genus seems most closely allied to the genus *Cythere*, in its modern restricted sense, and agrees with it in the general conformation of the shell and in most of the internal parts. The remarkable differentiation of the thoracic legs, particularly that of the third leg, which seems to be unique in the literature, makes it seem necessary to establish a separate genus.

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ENTOMOLOGY.—*A new genus of Trypetidae near* Anastrepha (*Diptera*).[1] ALAN STONE, U. S. Bureau of Entomology and Plant Quarantine.

A study of species heretofore placed in the genus *Anastrepha* has revealed a number that differ rather widely in structure from the genotype. Certain of these belong to the subgenus *Pseudodacus* Hendel, which I believe to be worthy of generic status and which I shall treat in a later paper. The others I place in the genus described in this paper. Eight previously described species and three new ones are included.

Certain terms in this paper may require explanation. The *wing pattern* is considered to consist of three bands, which become somewhat coalescent in certain species, broken or incomplete in others. The *costal band* extends along the anterior margin from the base of the wing to the apex of vein R_1; the **S**-band and the **V**-band are as designated by previous writers. The *ovipositor* is a sclerotized, subcylindrical tube with an acute apex, lying in a cylindrical, tapering, *ovipositor sheath*, the seventh abdominal segment. The eighth abdominal segment is membranous, is invaginated into the end of the ovipositor sheath, and bears denticles dorsally which form the *rasper*. Since the abdomen is often bent in mounted specimens, the total length of the body is difficult to determine. For this reason I have used instead, to indicate the size of the species, the length of the mesonotum from its anterior margin to the apex of the scutellum.

The writer is particularly indebted to A. C. Baker, of the Division of Fruitfly Investigations, Bureau of Entomology and Plant Quarantine, who first proposed the segregation of this genus, for specimens of the two new Mexican species; to James Zetek of the same Division for the new species from Panama; to John Smart, of the British Museum, for valuable information on the type of *Trypeta acidusa* Walker; and to A. da Costa Lima, of the Instituto Oswaldo Cruz, Rio de Janeiro, for information on a number of his species.

Lucumaphila, n. gen.

Agreeing in structure and chaetotaxy with *Anastrepha* (type, *Dacus serpentinus* Wiedemann) except for the following: Ovipositor sheath more slender; denticles of rasper usually all minute, long hooks absent, or, if the denticles are longer (0.1 mm), straight with blunt apices, not hook-shaped; ovipositor extremely slender, subcylindrical, the shaft about 0.05 mm or less in diameter; claspers of male rounded apically, the teeth subapical; aedeagus very slender, 1–2 mm long, reaching well beyond apex of claspers but considerably shorter than ovipositor; tip of aedeagus simple, membranous.

[1] Received March 29, 1939.

Genotype.—*Lucumaphila sagittata*, n. sp.

Distribution.—Neotropical Region from the Rio Grande Valley, Tex., to Brazil. The host fruits of only two species are known, both belonging to the genus *Lucuma* of the family Sapotaceae.

The species are medium sized to rather large and predominantly yellow-brown in color. The wing pattern is essentially similar to that found in many species of *Anastrepha* and not reduced or modified as in *Pseudodacus*. The microchaetae usually present on the dorsal surface of the posterior portion of the alula in *Anastrepha* are absent in *Lucumaphila*. All but one species of *Lucumaphila* (*hamadryas*) has, in the female, a distinct, small, dark nodule dorsally on the eighth segment just distad of the end of the ovipositor sheath. Certain species of *Anastrepha* have the ovipositor nearly as slender as in the genus *Lucumaphila*, but in these species it is never both extremely slender and very long and the rasper is always well developed. In *Lucumaphila hamadryas*, new species, the denticles of the rasper are unusually large for the genus, but they are straight and blunt, not curved and tapering as in *Anastrepha*, and they differ only in size from the minute denticles of the other species of *Lucumaphila*. The modified wing pattern and large hooks of the rasper distinguish the females of *Pseudodacus*. The male terminalia in *Lucumaphila* are much as in *Pseudodacus*, but the aedeagus of *Pseudodacus* is always very much reduced, scarcely exceeding the claspers. In those species of *Anastrepha* in which the teeth of the male clasper are subapical, the aedeagus is always much stouter and longer than in *Lucumaphila*.

Within the genus *Lucumaphila* the male terminalia exhibit very few differences, at least in those species known to the writer. The aedeagus is 1 to 2 mm long, the exact measurement being very difficult to make. The distal portion is slightly enlarged, with the apex attenuate and without the sclerotized modifications present in *Anastrepha*. The claspers are very similar in most of the species, but in the three species the males of which are known to me a sclerotized structure at the junction of the claspers, at the point where the anal segment joins the clasper segment ventrally, shows some differences. This structure is figured, but its value can not certainly be determined until more specimens can be studied.

The ovipositor tip is sagittate in several species, but the character is frequently difficult to see because the extracted, mounted ovipositor tends to lie on its side or will turn on its side even after mounting. Also, the ovipositor is so slender and delicate that extracting it without breaking off the tip is difficult.

KEY TO SPECIES

1. Costal and **S**-bands of wing widely separated.....2
   Costal and **S**-bands of wing touching to broadly confluent.....3
2. Ovipositor shaft about 0.025 mm wide, the tip very slender; two brownish spots on posterior margin of mesoscutum; **V**-band broken anteriorly.....1. *luederwaldti* (Costa Lima)
   Ovipositor shaft about 0.05 mm wide, the tip broader, with fine serrations; no dark spot on posterior margin of mesoscutum; **V**-band complete.....2. *hambletoni* (Costa Lima)
3. Bands on apical half of wing broadly confluent and somewhat diffuse; cell *R* completely infuscated.....3. *obscura* (Aldrich)
   V-band distinct; cell *R* partially hyaline.....4

4. Mesoscutum with two or three distinct black spots on posterior margin . . . . . 4. *dentata*, n. sp.
   Mesoscutum not spotted with black, although a dark brown band or diffuse brownish spots may be present posteriorly 5
5. Costal and **S**-bands very broadly coalescent along vein R_{4+5}; the hyaline area in cell *R* greatly reduced; cell *M* infuscated; **V**-band narrowly joined to **S**-band at vein *M* . . . . . 5. *urichi* (Greene)
   Costal and **S**-bands joined more narrowly along vein R_{4+5}; the hyaline area in cell *R* larger; cell *M* hyaline; **V**-band separated from **S**-band at vein *M* 6
6. **V**-band separated from **S**-band; denticles of rasper of female rather large, about 0.1 mm long . . . . . 6. *hamadryas*, n. sp.
   At least proximal arm of **V**-band joined to **S**-band; denticles of rasper of female much smaller 7
7. Distal arm of **V**-band slightly narrower at wing margin than it is near anterior end; hind margin of **S**-band subparallel to proximal margin of inner arm of **V**-band from vein R_{4+5} to fold in cell first M_2 . . . . . 7. *sagittata*, n. sp.
   Distal arm of **V**-band of uniform width, narrowed anteriorly, or greatly reduced, in any case usually disconnected from proximal arm; **S**-band and proximal arm of **V**-band divergent from near their juncture 8
8. Ovipositor sheath 8 mm long; macrochaetae of dorsum of thorax black; vein M_{1+2} but little turned forward at wing margin . . . . . 8. *longicauda* (Costa Lima)
   Ovipositor sheath less than 7 mm long; macrochaetae of dorsum of thorax orange-brown; vein M_{1+2} with the normal forward curve 9
9. Ovipositor sheath more than 5.5 mm long . . . . . 9. *hamata* (Loew)
   Ovipositor sheath about 4 mm long . . . . . 10. *zernyi* (Costa Lima)

Lucumaphila acidusa (Walker) would run to couplet 9 in this key, but since the ovipositor sheath and ovipositor are incomplete it can not be keyed further.

1. Lucumaphila luederwaldti (Costa Lima), n. comb.

Anastrepha luederwaldti Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 510, figs. 15–16, pl. 66, fig. 18, pl. 76, fig. 67, 1934.

Medium sized, yellow-brown. A pair of castaneous spots on apical margin of mesoscutum; metanotum entirely yellow-brown. Macrochaetae pale yellow. Sternopleural bristle well developed. Wing 7.75 mm long, the costal, **S**-, and **V**-bands all separated and the **V**-band broken anteriorly, neither arm crossing vein R_{4+5}; vein M_{1+2} only slightly turned forward at apex. *Female:* Body, exclusive of ovipositor sheath, 6.5 mm. Ovipositor sheath 3 mm long, tapering. Ovipositor about 0.025 mm wide, the tip tapering and with no serrations. *Male:* Tip of clasper obtuse, turned slightly caudad, the teeth subapical.

Cotypes.—Two females, two males (Museu Paulista, São Paulo).

Type localities.—São Paulo, Ypiranga, and Alto da Serra, Brazil.

Distribution.—Known only from the foregoing localities, all in southern Brazil.

Remarks.—I have not seen this species, the above description being based upon the original one. The slender ovipositor and character of the rasper make its assignment to this genus rather certain.

2. **Lucumaphila hambletoni** (Costa Lima), n. comb.

Anastrepha hambletoni Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 519, fig. 19, pl. 67, fig. 21, 1934.

Medium sized, yellow-brown, the mesoscutum with pale-yellow stripes. Total length, exclusive of ovipositor sheath, 7 mm. Macrochaetae castaneous. Sternopleural bristle present. Wing 7 mm long, the costal, **S**-, and **V**-bands all separated; **V**-band complete; vein R_{2+3} slightly undulant. *Female:* Ovipositor sheath 5 mm long, slender, tapering. Ovipositor long, slender, the shaft about 0.05 mm wide; tip narrowed rather abruptly, with a few fine serrations.

Holotype.—Female (Instituto Oswaldo Cruz, Rio de Janeiro).

Type locality.—Viçosa, State of Minas Geraes, Brazil.

Distribution.—Known only from the single specimen.

Remarks.—I have not seen this species, the above description being based on the original one. The dimensions of the body and wing were not given in the original description but have been furnished me by Dr. Costa Lima.

3. **Lucumaphila obscura** (Aldrich), n. comb.

Anastrepha obscura Aldrich, Proc. U. S. Nat. Mus. **66** (18): 5, 1925.—Greene, Proc. Ent. Soc. Washington **36**: 157, pl. 21, fig. 2, 1934.—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 500, 1934.

Large, orange-brown. Mesonotum 4.6 mm long, orange-brown, the mesoscutum with indistinct paler stripes; no black on metanotum. Macrochaetae orange-brown; pile yellow. Sternopleural bristle very weak. Wing (Fig. 10) 10.5 mm long, orange-brown, except for a hyaline triangle on costa beyond stigma and pale spots on posterior margin of wing in cells second M_2, Cu_1, and anal, the spot in Cu_1 extending forward faintly to vein R_{4+5}; in one specimen a fenestrate spot in cell R_{2+3} beyond costal hyaline spot. *Female:* Ovipositor sheath 6.5 mm long, the basal half somewhat swollen, tapering to the slender apical half; spiracles about 1.1 mm from base. Ovipositor 5.5 mm long, very slender, the shaft about 0.035 mm wide, slightly swollen before apex; tip as in figure 1. *Male:* Tip of clasper acute in lateral view. Cephalic view as in figure 7.

Holotype.—Female (U. S. National Museum).

Type locality.—Maraval, Trinidad.

Distribution.—Trinidad and Brazil.

Host plant.—*Lucuma multiflora.*

Remarks.—In addition to the original specimens there is a male from Trinidad, March 5, 1919 (F. W. Urich), in the U. S. National Museum and a female from Brazil (H. W. Bates) in the British Museum. The species is easily recognized by its wing pattern.

4. **Lucumaphila dentata,** n. sp.

Medium sized, yellow-brown, with black spots on mesoscutum. Mesonotum 3.58 mm long, pale yellow, the mesoscutum with four orange-brown stripes, the outer pair extending from behind humeri to lateral angles of

scutellum, narrower posteriorly and coalescent with inner pair anteriorly; two inner stripes extending about three-fourths of distance from anterior margin to scutellum and separated by a median line which narrows anteriorly, leaving a transverse, pale-yellow area anterior to scutellum with a median projection to anterior margin of mesonotum and narrow lateral projections, fading out anteriorly; at posterior end of each lateral orange-brown stripe a black spot, concave on inner and anterolateral margins,

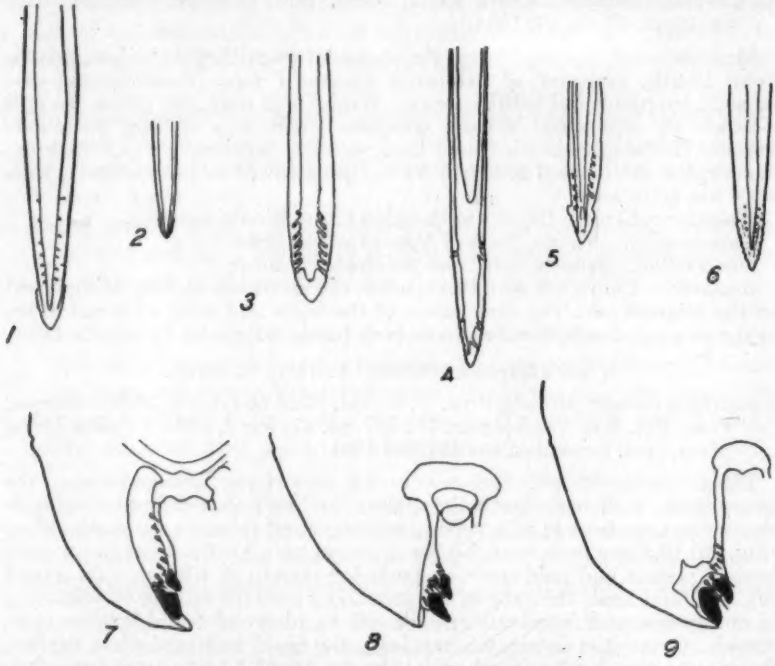

Fig. 1.—Ovipositor tip of *Lucumaphila obscura* (Aldrich). Fig. 2.—Ovipositor tip of *L. dentata*, n. sp. Fig. 3.—Ovipositor tip of *L. urichi* (Greene). Fig. 4.—Ovipositor tip of *L. hamadryas*, n. sp. Fig. 5.—Ovipositor tip of *L. sagittata*, n. sp. Fig. 6.—Ovipositor tip of *L. hamata* (Loew). Fig. 7.—Right male clasper of *L. obscura* (Aldrich). Fig. 8.—Right male clasper of *L. sagittata*, n. sp. Fig. 9.—Right male clasper of *L. hamata* (Loew).

convex on posterolateral margin; holotype and female paratype only faintly brownish on scutoscutellar suture medianly; male paratype with a pronounced brownish-black spot; pleura predominantly pale yellow; metanotum uniformly yellow-brown. Macrochaetae yellow-brown; pile yellow. Sternopleural bristle present, slender. Wing (Fig. 11) 8 mm long, the bands yellow-brown; costal and **S**-bands united a short distance on vein R_{4+5}; **V**-band complete, joined to **S**-band anteriorly. *Female:* Ovipositor sheath 2.6 mm long, evenly tapering apically; spiracles 0.67 mm from base. Ovipositor very slender, the shaft about 0.0175 mm wide; length unknown, as it is complete in neither female; tip as in Fig. 2. *Male:* Terminalia accidentally lost.

Holotype.—Female. Paratypes, one male, one female (U. S. N. M. no. 51649).

Type locality.—Tequila, Jalisco, Mexico.

Distribution.—Jalisco, Mexico; Texas.

Remarks.—The holotype and male paratype formed part of the material obtained as a result of a trip by A. C. Baker and Alfons Dampf to Tequila in the latter part of July 1934. The name *dentata* is the manuscript name under which Dr. Baker figured the species in an unpublished report, chosen in reference to the toothlike black spots on the mesoscutum. The female paratype was collected at San Juan, Tex., February 20, 1935, by Burl Stugard. The ovipositor sheath of this specimen is the one described, as the sheath of the holotype was not preserved by Dr. Baker.

5. **Lucumaphila urichi** (Greene), n. comb.

Anastrepha urichi Greene, Proc. Ent. Soc. Washington **36**: 159, pl. 22, fig. 1, 1934.

Rather large, yellow-brown. Mesonotum 4.39 mm long. Entire thorax uniformly yellow-brown. Macrochaetae orange-brown; pile pale yellowish brown. Sternopleural bristle very weak. Wing (Fig. 12) 9.25 mm long, the venation normal; wing bands orange-brown, the hyaline area between apical portion of **S**-band and distal arm of **V**-band distinctly constricted at vein R_{4+5}; **V**-band broad, broadly connected with **S**-band anteriorly and narrowly so on vein *M;* costal and **S**-bands broadly coalescent; cell *M* infuscated. *Female:* Ovipositor sheath 4.87 mm long, the apical third distinctly narrower than the posteriorly tapering basal two-thirds; spiracles 1.33 mm from base. Ovipositor 4.25 mm long, extremely slender, the shaft about 0.029 mm wide; tip slightly widened, with the apex rounded and indistinctly serrate (Fig. 3).

Holotype.—Female (U. S. National Museum).

Type locality.—Trinidad.

Distribution.—Known only from the single specimen.

6. **Lucumaphila hamadryas,** n. sp.

Large, yellow-brown. Mesonotum 4.9 mm long. Mesoscutum pale yellow, with four rather indistinct orange stripes, the median pair not reaching to acrostichal bristles posteriorly; a darker orange-brown, transverse band in front of scutellum; scutellum and pleura pale yellow; metanotum orange-yellow. Macrochaetae black; pile pale yellow-orange. No sternopleural bristle. Wing (Fig. 15) 11.5 mm long, the pattern mostly brown, the costal and **S**-bands joined for a short distance on vein R_{4+5}; **V**-band rather heavy, narrowed but not broken at apex, narrowly separated from **S**-band. *Female:* Ovipositor sheath 6.5 mm long, slender, tapering, the spiracles about 1.34 mm from base. Ovipositor 5.53 mm long, the shaft about 0.035 mm wide, the base abruptly widened, the tip long, slender, with minute serrations apically (Fig. 4).

Holotype.—Female (U. S. N. M. no. 51650).

Type locality.—La Campana, Panama.

Distribution.—Known only from the type specimen.

Remarks.—The type was collected in a glass trap in Muñoz Grove, La Campana, January 7, 1939, by James Zetek, who wrote, "The single large female is the largest *Anastrepha* yet collected by us. . . ." As indicated previously, this species shows certain features of the eighth segment and

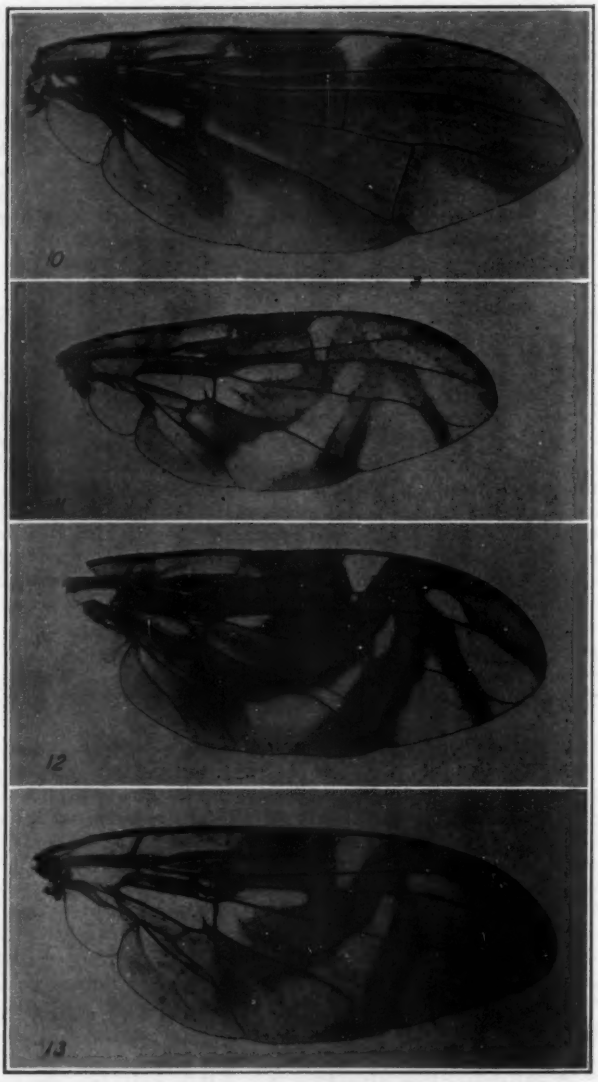

Fig. 10.—Wing of *Lucumaphila obscura* (Aldrich). Fig. 11.—Wing of *L. dentata*, n. sp. Fig. 12.—Wing of *L. urichi* (Greene). Fig. 13.—Wing of *L. hamata* (Loew).

rasper rather different from other species of the genus, but the shape of the rasper denticles and the character of the ovipositor place it in *Lucumaphila*.

7. Lucumaphila sagittata, n. sp.

Rather large, predominantly yellow-brown. Mesonotum 4.5 mm long. Mesoscutum orange-yellow, with humerus, a sublateral stripe from transverse suture to scutellum, and an area in front of acrostichal bristles having a narrow median extension anteriorly, pale yellow; a brown transverse band on scutoscutellar suture, most of it anterior to suture; pleura pale yellow; metanotum orange-yellow. Macrochaetae orange-brown; pile pale yellow. No sternopleural bristle. Wing (Fig. 14) 9.9 mm long, the pattern orange-brown, the costal and **S**-bands rather narrowly connected; **V**-band rather narrowly connected to **S**-band; distal arm of **V**-band widest just behind connection with the proximal arm, narrowing to the posterior margin. *Female:* Ovipositor sheath 4.5–5.2 mm long, slender, tapering, slightly curved upward, the spiracles about 1.11 mm from base. Ovipositor 3.9–4.5 mm long, the shaft about 0.028 mm wide; tip scarcely wider than shaft, sagittate (Fig. 5). *Male:* Clasper stout, the apex blunt in lateral view; cephalic view as in Fig. 8.

Holotype.—Female. Paratypes, 15 females, 5 males (U. S. N. M. no. 51651).

Type locality.—Cuernavaca, Mexico.

Distribution.—Texas to Panama.

Host plant.—According to Dr. Baker this species has been reared from the seeds of *Lucuma* in Mexico, but I have seen no reared specimens.

Remarks.—The holotype was trapped at Cuernavaca in September 1933 by M. McPhail; 15 paratypes were trapped at the same locality in September 1933 and November 1934; 4 paratypes were trapped at Mission, Tex., January 6, 1938, by D. O. Sikes; one paratype was trapped at Balboa, Canal Zone, in September 1938 by James Zetek. The name of this species, suggested by the strongly sagittate tip of the ovipositor, is the manuscript name under which Dr. Baker figured and described the species in an unpublished report.

8. Lucumaphila longicauda (Costa Lima), n. comb.

Anastrepha longicauda Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 525, fig. 23, pl. 48, fig. 25, pl. 74, fig. 53, 1934; O Campo **8**: 38, 1937.

Large, yellow-brown. Mesoscutum yellow-brown with no pale stripes; metanotum with two brownish, transverse streaks on each side. Macrochaetae black. No sternopleural bristle. Wing 10.5 mm long, the costal and **S**-bands narrowly touching on vein R_{2+3}; proximal arm of **V**-band rather broadly joined to **S**-band anteriorly; distal arm slender, separated from proximal arm anteriorly; vein M_{1+2} but little turned forward at apex. *Female:* Body, exclusive of ovipositor sheath 9.5 mm long. Ovipositor sheath 8 mm long, slender. Ovipositor about 6.9 mm long, very slender, the shaft about 0.04 mm in diameter; the tip is figured by Costa Lima as being no wider than the shaft, without teeth or processes, but it is probable that the view is a lateral one.

Holotype.—Female (Instituto Oswaldo Cruz).

Type locality.—S. Gabriel, Rio Negro, Amazonas, Brazil.

Distribution.—Known only from the type specimen.

Remarks.—The above description is based upon the original description, since I have not seen the species.

9. **Lucumaphila zernyi** (Costa Lima), n. comb.

Dacus parallelus Wiedemann (part), Aussereuropaische zweiflugelige Insecten **2**: 515, 1830.

Anastrepha zernyi Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 425, pl. 62 fig. 2–3, 1934; O Campo **8**: 38, 1937.

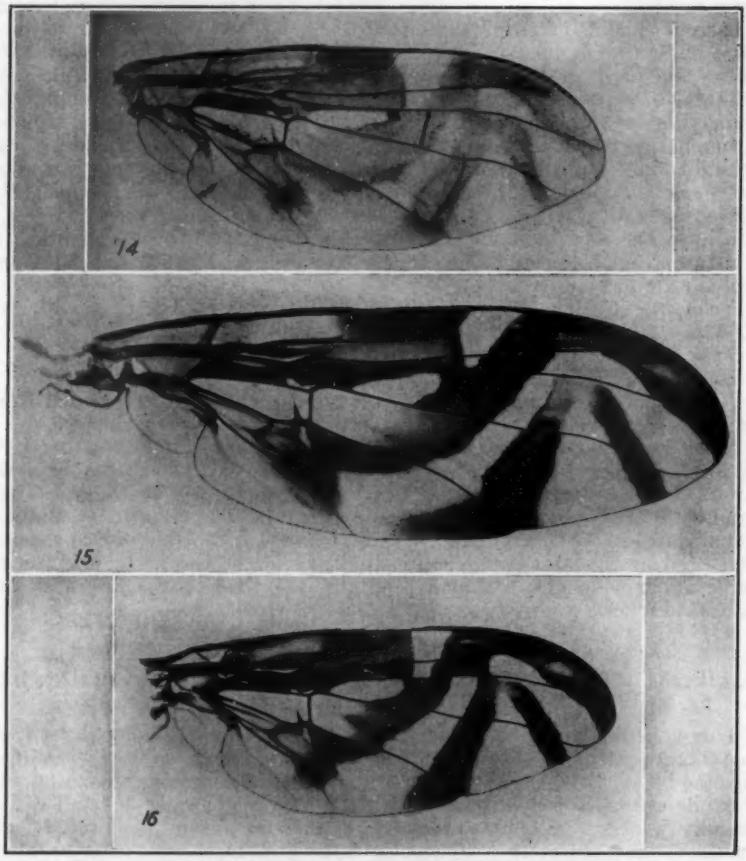

Fig. 14.—Wing of *Lucumaphila sagittata*, n. sp. Fig. 15.—Wing of *L. hamadryas* n. sp. Fig. 16.—Wing of *L. acidusa* (Walker) (photo by John Smart).

Rather large, yellow-brown. Mesonotum 3.9 mm. long. Thorax yellow-brown, a small brownish spot on mesoscutum just anterior to corner of scutellum. Macrochaetae orange-brown; pile yellowish brown. Sternopleural bristle slender. Wing 8.5 mm long, the bands yellow-brown; costal and **S**-bands narrowly touching; proximal arm of **V**-band rather broadly joined to **S**-band anteriorly. *Female:* Ovipositor sheath 4 mm long, slender, the

spiracles 0.97 mm from base. Tip of ovipositor lost in the specimen before me.

Holotype.—Female (Naturhistorisches Museum, Vienna), cotype of *Dacus parallelus* Wiedemann.

Type locality.—Brazil.

Distribution.—Brazil.

Remarks.—Besides the type, this species is known only from a pair in the American Museum of Natural History, collected at Chapada, Brazil, which I believe belong to this species. The foregoing description is based upon these latter specimens. The species agrees very closely with *hamata* save for the distinctly shorter ovipositor. The male has lost most of its abdomen.

10. **Lucumaphila hamata** (Loew), n. comb.

Trypeta hamata Loew, Smithsonian Misc. Coll. No. 256: 229, pl. 11, fig. 22, 1873.

Anastrepha hamata (Loew), Bezzi, Boll. Lab. Zool. Gen. Agr. Portici **3**: 284, 1909.—Hendel, Abh. Ber. Zool. Anthr.-Ethn. Mus. Dresden **14**(3): 14, 1914.—Greene, Proc. Ent. Soc. Washington **36**: 157, pl. 2, fig. 3, 1934.—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 524; O Campo **8**: 38, 1937.

Large, yellow-brown. Mesonotum 4.5–4.8 mm long. Thorax yellow-brown, slightly darker just anterior to scutoscutellar suture; metanotum not or little darkened laterally. Macrochaetae orange-brown; pile yellowish brown. Sternopleural bristle very weak or absent. Wing (Fig. 13) 9.8–11.2 mm long; costal and **S**-bands joined for a short distance along vein R_{2+3}; proximal arm of **V**-band rather narrowly joined anteriorly to **S**-band; distal arm more or less reduced, often confined to a small streak near hind margin, but occasionally narrowly connected to proximal arm. *Female:* Ovipositor sheath 6–7.25 mm long, slender, the spiracles 1.22 to 1.44 mm from base. Ovipositor 5.2–6 mm long, very slender, the shaft about 0.026 mm in diameter, the tip slightly expanded, serrate as in Fig. 6. *Male:* Claspers stout, the apex blunt in lateral view; cephalic view as in Fig. 9.

Cotypes.—Male and female (location unknown).

Type locality.—Brazil.

Distribution.—Brazil and Panama.

Remarks.—The above description is based upon six specimens in the United States National Museum which appear to belong to this species. The data for these specimens are as follows: Brazil (Compere); Amazon River, Arary to Manaos, Brazil, September 20–21, 30 (Holt, Blake, and Agostini); Barro Colorado Island, Canal Zone, September 17, 1937 (Zetek); La Campana, Panama, November 1937 (Zetek); Balboa, Canal Zone, June 1938 (Zetek).

11. **Lucumaphila acidusa** (Walker), n. comb.

Trypeta acidusa Walker, List of the specimens of dipterous insects in the collection of the British Museum **4**: 1014, 1849.

Anastrepha acidusa (Walker), Aldrich, Smithsonian Misc. Coll. No. 1444: 602, 1905 (part).—Costa Lima, Mem. Inst. Oswaldo Cruz **28**: 530 and 604, 1934.

I have not positively recognized this species. The type has lost a portion of the ovipositor sheath and ovipositor so that the length of these and the

character of the rasper are unknown. Dr. Smart has mounted the remnants of the ovipositor sheath and ovipositor and sent photographs to me. The shaft of the ovipositor is about 0.021 mm wide and this extreme slenderness combined with the general appearance makes assignment to this genus quite certain. The species would run to *hamata* in the key and seems to agree in every particular save that the V-band is complete, a condition unusual in *hamata*. Dr. Smart also photographed the wing of the type (Fig. 16). The pattern of the missing portion is indicated by stippling as it appears on the opposite wing.

Holotype.—Female (British Museum).

Type locality.—Jamaica.

Remarks.—It is to be hoped that the species can again be collected in Jamaica so that it can be more fully described. The name *Anastrepha acidusa* has been used a number of times for the species that Sein described as *A. mombinpraeoptans*, and the Florida record mentioned by Aldrich is probably this latter species. *A. mombinpraeoptans* has an unusually short ovipositor and in a number of other respects is quite different from the species described by Walker.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

566TH MEETING

The 566th meeting was held at the Cosmos Club, November 9, 1938, President H. D. MISER presiding.

Program: E. B. ECKEL: *Abutment problems at Zuni dam, New Mexico.*—The Zuni dam is an outstanding example of the fact that no dam can be better than its natural foundations. It is built in a narrow gorge that has been cut through a 30-foot basalt flow and into underlying alluvium. A bed of loose sand lies between the base of the flow and a layer of tough clay. The abutments have caused trouble ever since the reservoir was first filled. The most serious difficulties occurred in 1909 and 1936, when large leaks broke out on the south abutment. Both resulted in cracking and settlement of the lava cap and loss of reservoir water. A cut-off wall, built after the first break, was effective for 27 years. The leaks were caused when water entered openings in the basalt and reached the sand layer. This layer acted like a broad, flat pipe and led the water to an outlet below the dam. The sand was flushed out, allowing the spillway and abutment to settle. After the 1936 break, a combination dike and blanket was laid along the south abutment in order to prevent entrance of water into the basalt. The new structure has been tested only for a short time but will apparently be effective. Several geologic problems involved in the repair work were discussed by the speaker.

C. P. ROSS: *Some comments on the geology of quicksilver.*—Quicksilver deposits are widely distributed but so irregular and individually small that it is difficult to prospect for them or to block out ore in advance. Even more than other metals, they are deposited far from their original sources and in areas relatively free from commercial deposits of other metals. Most of the production has come from a small percentage of the known lodes. The deposits are localized where structural conditions furnish comparatively

abundant openings in the rocks and where decrease in temperature and pressure and, at least in some places, mingling with acid groundwater, promote precipitation. In some places, concentration into deposits of commercial grade is assisted by structural traps.

J. S. WILLIAMS: *Lower Permian of the type area, U.S.S.R.*—Members of the Permian excursion of the Seventeenth International Geological Congress in the U.S.S.R., visited the typical region of the Permian system of Murchison and of the Artinskian, Kungurian, Ufimian, Kazanian, and Tartarian subdivisions. Murchison's original Permian included beds down to the base of Kungurian. He placed the Artinskian or Artinsk grits in the top of the Upper Carboniferous. Karpinsky described cephalopods from these grits from several localities, some of which (especially those from the Orenburg region about 350 miles south of Artinsk) he recognized were from beds that were of Artinskian facies but older than the beds at Artinsk. Later work has shown that in places beds of Artinskian facies go as far down as to the Lower Carboniferous. Tschernyshew, in 1904, published his work on the Upper Carboniferous brachiopods of the Urals and Timan. In this influential work he placed the top of the Upper Carboniferous immediately above his "*Schwagerina*" zone. Both Karpinsky and Tschernyshew considered the Artinskian as Permo-Carboniferous, as also did the Central Geological Committee.

The Permian is currently divided into a twofold division by geologists of the U.S.S.R. The Lower Permian in the type region now consists of an upper, Kungurian, subdivision and a lower, Artinskian, subdivision. The Upper Carboniferous has been generally known as the Uralian. Geologists differ regarding the horizon at which the boundary between the Uralian and the Artinskian should be placed and some would place a new division, the Sakmarian, between them. In the U.S.S.R., as in the United States, several boundaries between the Permian and Carboniferous each have adherents. Three boundaries have, however, the most adherents in the U.S.S.R. The highest of these is immediately below the zone commonly referred to as the *Pseudofusulina lutugini* zone, correlated with the Phosphoria and Word formations of the United States by some and with the Upper Leonard by others. The next highest boundary is immediately below the *P. anderssoni* zone, which is itself immediately below the *P. lutugini* zone. The *P. anderssoni* zone has been correlated with part or all of the Leonard formation of the United States. Below the *P. anderssoni* zone is the *P. moelleri* zone and below that zone is the well-known so-called "*Schwagerina*" (now *Pseudoschwagerina*) zone. These zones together probably comprise the Sakmarian, proposed by Rutzensev from studies in the Orenburg region. The lowest of the principally advocated boundaries is immediately below the so-called "*Schwagerina*" zone.

From publications the writer has read and from impressions gained in the U.S.S.R., he believes that the boundary below the *P. lutugini* zone is the most widely used in the U.S.S.R., but no statistical evidence was obtained. Reasons advanced by various Soviet geologists for placing the Permian-Carboniferous boundary here include the following: A bryozoan specialist would place it here because of a discontinuity in bryozoan development; a fusulinid specialist, because of a discontinuity in the sequence of fusulinids; and a coral specialist, because of the appearance of certain peculiar corals. Others cite changes in certain plants, the fact that a sharp change in lithology and an unconformity come at the base of the *P. lutugini*

zone near Artinsk, and the presence of stratigraphic breaks at places on different continents approximately at this horizon.

Soviet geologists who would place the boundary immediately above the *P. moelleri* zone cite the following among their reasons for doing so: A fusulinid specialist believes the fusulinids below this boundary are more closely related to Upper Carboniferous than to younger fusulinids. This same geologist states that a sharp change in geographic and sedimentary conditions and diastrophic processes begins here, that it is very convenient to place the boundary here because of the ease with which underlying beds can be identified, and that Murchison's lower Artinskian boundary was above this zone. Another geologist would place it here because Tschernyshew, who has been widely followed both in official and other reports, placed the Upper Carboniferous boundary above the *Schwagerina* zone. Still another would place it here because of an unconformity above the "*Schwagerina*" zone.

Rutzensev and Nalivkin are the chief Soviet advocates of placing the boundary at the base of the so-called *Schwagerina* zone. They advocate this boundary because they believe that the ammonoids of this zone are more closely related to younger than to older rocks, because of a discontinuity in the sequence of fusulinids; because Karpinsky described as Artinskian certain cephalopods found in *Schwagerina*-bearing beds in the South Urals, which are of Artinskian facies (even though Karpinsky did recognize that these cephalopods were older than those of the Artinskian at Artinsk), and because certain coral genera which occur in undisputed Permian beds elsewhere occur in the *Schwagerina* beds. Another cephalopod specialist would place it here mainly because of discontinuities in the cephalopod development, and a Soviet coral specialist would also place it here. Other arguments were advanced chiefly by foreign geologists.

The number of boundaries advocated, each of which seems most logical if certain selected criteria are used or if the emphasis of a single criterion is favorably placed, suggests that an agreement on criteria to be used is the first step in the solution of the problem of the lower Permian boundary. Few would suggest holding strictly to priority, the most easily followed criterion. Lacking such an agreement also on other criteria, as at present, preponderance of the usage followed in the type region seems to promise as nearly a satisfactory standard as it is possible to obtain. Restriction of the standard to the type region would localize the problem in an area that could be studied in detail and would put the determination of period standards essentially on the basis that is generally used in interpreting disputed details about formations. If world-wide opinion should demand a change to some other sequence than that of the present type region as a standard because of the absence of intermediate beds in the type locality, which does not seem to be likely, or if world opinion should demand the use of some boundary other than that generally used in the type region, because of agreement upon a more satisfactory boundary the world over or for some other reason, recourse could then be had to a world-wide representative vote or to such an organization as the International Geological Congress, which has considered similar problems. It seems likely, however, that if world-wide opinion were decidedly against the boundary commonly used in the type region, it would force a change there without the necessity of action by an International Geological Congress.

As stated earlier, the original Permian of Murchison extended down to include the Kungurian. In the early part of this century, the Central Geo-

logical Committee placed the Kungurian and Artinskian in the Permo-Carboniferous. In 1917, they transferred these beds to the Permian. Tschernyshew's work has been most widely followed since its publication, but the use of his classification is hindered because part of his section is said to have been misinterpreted and because some maintain that "*Schwagerina*" is not a narrow-zone fossil as once thought but ranges through a considerable section in some places and occurs in beds that are of different ages in different places. It is the writer's distinct impression that most Permian stratigraphers in the U.S.S.R. now place the boundary above the "*Schwagerina*" zone as it is generally interpreted, and that it is so placed in most official publications of the Central Geological and Prospecting Institute.

Because there seems to be some indication that present opinion in the U.S.S.R. may change and because many geologists in the United States place the boundary below the "*Schwagerina*" zone, the writer continues to advocate, as he has since 1936, that some group name be selected for this zone, that this group be designated temporarily as Pennsylvanian or Permian, and that correlations be made mainly in terms of the group units with less emphasis being placed on the location of the Pennsylvanian-Permian boundary. The widespread use of such group units as reference points for correlations would restrict our problems mainly to areas in the United States that can be visited repeatedly and studied in detail. It would fully serve the needs of most geologists, because most geologists are interested mainly in local and perhaps sectional correlations. These are only confused if the details of international problems inherent by definition in the setting of period standards and the drawing of period lines are introduced into local controversies.

567TH MEETING

The 567th meeting was held at the Cosmos Club, November 23, 1938, President H. D. MISER presiding.

Informal communications.—Mr. J. B. MERTIE described the Dufay and Kodachrome processes of making colored transparencies and projected a number of Dufay color photographs that he had taken in Alaska during the past field season.

Program: R. C. CADY: *Erosional history of the North Platte Valley in Nebraska.*—The North Platte River in the region of Scotts Bluff County, western Nebraska, has cut its valley over 1,000 feet below the upper level on the plains. Gravel occurs on the high level of the plain north of the river, and as the river eroded the valley the gravel was washed down the valley sides. This gravel cover protected the terrace surfaces from erosion and thus aided in their preservation. The upland plain south of the river furnished much less gravel than that to the north, with the result that the terrace surfaces on the south side were not preserved, and the south side of the valley is steeper than the north side.

Six terrace levels can be recognized, including the gravel remnants on the upland. The fifth level (numbered from lowest to highest) is a steep, convex slope covered with coarse gravel. It seems to represent the greatest part of the Pleistocene erosion. Four substages are suggested by breaks in slope on this surface, the lowest being a line of hillocks 300 feet or more above the level of the river. The fourth terrace level is a rock bench covered with gravel. The surface of the third terrace is 80 to 100 feet above the present level of the river. After its formation the river and tributary streams cut deep, narrow trenches into it. The river cut down about 300 feet, but the

tributary gulches were not cut so deeply. Before they could be widened very much they were refilled with gravel. The bottom of the channel that was cut and refilled by the river now lies about 200 feet below the present level of the river. After the channels were refilled the river began to cut down again, and to widen its inner valley by lateral corrasion. It reached grade at a level 40 to 50 feet below the surface of the third terrace. The tributary streams also cut down but not so deeply as the river. Fine-grained sediments were deposited in the newly eroded valleys, partially filling them. The remnants of this fill constitute the second terrace. The river and tributary streams were again rejuvenated and they began to cut through this fill. Most of the remnants of the second terrace were removed from the valley of the river, but they are still preserved in some of the tributary valleys. After about 20 to 30 feet of downcutting had taken place the new gullies were again partially filled with fine-grained sediment. Remnants of this fill constitute the first terrace. Since that time the streams have cut about 15 or 20 feet below the top of the first terrace.

The terraces, particularly the third, second, and first, possess characteristics that render them recognizable in other valleys in the region.

Little is definitely known of the age of the terraces. Vertebrate fossils are being collected from gravels on the fifth terrace, and they are considered to be early Pleistocene in age. Yuma artifacts in association with extinct bison have been taken from sediments that constitute the second terrace. Hearths and pottery of not very ancient date are found in the sediments of the first terrace. The second and first terraces are more similar to each other than to any of the older terraces. Also, more erosion took place in the interval between the third and second terraces than took place between the formation of the second terrace and the first. It is believed, therefore, that the second terrace may be late Wisconsin or early Recent in age.

M. M. KNECHTEL: *Large boulders and glacial striae near Little Rocky Mountains, Mont.*—Extending southeastward for at least 36 miles from Snake Butte, a prominent feature of the plains of the Fort Belknap Indian Reservation north of the Little Rocky Mountains, Mont., is a train of glacial boulders, many of which are very large. The igneous rock composing the boulders is identical with that exposed on Snake Butte, and on top of the butte glacial striae elongated southeastward indicate that the boulders were transported by the glacier and not, as has been supposed, by icebergs floating in water ponded between the ice front and the high land at the base of the Bearpaw and Little Rocky Mountains. As there are reasons for believing that the Keewatin ice sheet advanced into the Montana plains from the northeast, deflection of the ice southeastward by the Bearpaws and Little Rockies is indicated.

J. T. PARDEE: *Post-Tertiary faulting of intermontane basins, western Montana.*—The region considered is part of the physiographic province known as the Northern Rocky Mountains. The principal mountain group and ranges within it attain altitudes of 10,000 feet or more and rise 4,000 to 6,000 feet above adjacent lowlands. The mountains are maturely dissected by narrow, steep-sided valleys but flat or gently sloping surfaces of noteworthy extent remain on many of the summits. Between the different mountain groups and ranges are 40 or more wide intermontane basins that aggregate 10,000 square miles or about one-fourth of the total area.

The intermontane basins are underlain largely by Tertiary and later sediments that rest unconformably on a bedrock floor eroded across strongly deformed older rocks that also compose the mountains. The structure of the

Tertiary sediments suggests downwarping in some of the basins and downfaulting in others. The idea of downfaulting is supported by the occurrence of fault scarps at one side or the other of several of the basins. Among these are low scarps of Recent age in the Madison, Centennial, and Red Rock (Lima) Valleys that are formed in unconsolidated alluvium and glacial deposits. Others are more or less worn scarps in the older rocks that form certain mountain fronts. Some of these mark vertical displacements of as much as 5,000 or 6,000 feet. The two severe earthquakes recorded in this region within the past 15 years appear to have been caused by movements on faults, marked by the older scarps only belonging to a system along the eastern side of the mountain province.

568TH MEETING

The 568th meeting was held at the Cosmos Club, December 14, 1938, Presient H. D. MISER presiding.

The prize for the best paper presented to the Society during the year was awarded to Mr. K. J. MURATA. The second prize was awarded to Mr. R. E. STEVENS.

Program: Presidential address by H. D. MISER: *Our petroleum supply.*—The United States produces and consumes three-fifths of the world's annual output of petroleum and it possesses about half of the world's known reserves. Our domestic petroleum production is obtained from about 360,000 wells in 22 States, and its value is one-fourth the value of the entire annual mineral production of the United States.

Petroleum and its associated hydrocarbons have been used by the peoples of many lands for at least several thousand years; and the history of their recovery, transportation, treatment, and utilization records a fascinating story of the progress of human civilization. The phenomenal growth of the petroleum industry in the United States since 1859, when our first well was drilled for oil, has been greatly aided by geology. The number of geologists now serving the industry in the United States, in the employ of companies and in the employ of Governmental, State, and other institutions, appears to exceed 3,000. The oil geologist, in the search for petroleum, makes use of facts and conclusions from many phases of geology, including structure, stratigraphy, paleontology, sedimentary petrology, sedimentation, geomorphology, and metamorphism; and, because of the vast amount of information obtained from deep wells, as much as 15,004 feet in depth, and from the 30,000-foot depths reached by geophysical methods, he has made notable contributions to the general science of geology.

46TH ANNUAL MEETING

The 46th annual meeting of the Society was held immediately following the 568th regular meeting. The reports of the secretaries, the auditing committee, and the treasurer were read and approved.

The Society elected the following officers for the year 1939:

President: J. B. MERTIE, JR.
Vice Presidents: J. B. REESIDE and J. T. PARDEE
Treasurer: T. B. NOLAN
Secretary: P. D. TRASK
Members-at-Large-of-the-Council: A. A. BAKER, R. W. BROWN, T. A. HENDRICKS, E. A. TRAGER, J. S. WILLIAMS.

The Society also appointed Mr. HUGH D. MISER its nominee for vice-president of the Washington Academy of Sciences.

J. W. GREIG, *Secretary*

Obituary

The death of WILLARD DELL BIGELOW on March 6, 1939, brought to its close the career of a distinguished pioneer in food research, whose passing is mourned by a great host of personal friends and scientific contemporaries the world over.

Dr. Bigelow was born at Gardner, Kansas, on March 31, 1866. He was graduated from Amherst in 1889, subsequently serving a short term as associate professor of chemistry at Oregon State College. This was followed by post-graduate work at Amherst, and in 1892 Dr. Bigelow accepted a position in the U. S. Bureau of Chemistry. In 1901 he was made chief of the Food Division of the Bureau of Chemistry, and in 1903 became assistant chief of the Bureau. Following enactment of the Federal Food and Drugs Act in 1906, he was associated with Dr. Harvey W. Wiley in the enforcement of the Act and had the primary responsibility for the selection of personnel of the new branch laboratories.

In 1913 he became associated, as chief chemist, with the newly organized research laboratories of the National Canners Association, and in 1918 he became the first director of the laboratories.

He was universally recognized as one of the leading authorities on foods and food legislation, and tribute was paid to his ability and learning by his election to many offices of distinction in scientific organizations and societies. He was for many years a director and counselor of the American Chemical Society, and he served as president of the Association of Official Agricultural Chemists and of the Association of Dairy and Food Officials.

Outstanding among his many services to the canning industry were his contributions to the study of the tin container, the nutritive value of canned foods, and the fundamental methods for establishing safe processes for all classes of canned foods.

Dr. Bigelow was respected by all for his wise counsel, upright character, and sound judgment; his kindliness and courtesy won the friendship and affection of those with whom he came in contact.

In 1901 he was married to Miss Nancy M. Nesbit, who, with their two daughters, Miss May Thorpe Bigelow and Mrs. Jessie B. Martin, survives him.